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THE LARVAL INSTARS OF THE WHEAT MIDGE, *SITODIPLOSIS MOSELLANA* (GÉHIN) (DIPTERA: CECIDOMYIIDAE)

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Abstract.—The wheat midge, *Sitodiplosis mosellana* (Géhin), is shown to have three larval instars. Each instar is described and illustrated, the initial instar for the first time. An alleged synonym of the wheat midge, *Cecidomyia amyotii* Fitch, is removed from synonymy with the wheat midge and considered a dubious name.

Key Words: wheat midge, *Sitodiplosis,* larva

The wheat midge, *Sitodiplosis mosellana* (Géhin), is one of the two most important cecidomyiid pests of wheat in North America, the other being the Hessian fly, *Mayetiola destructor* (Say). Originally from the Palearctic Region, both are now well established in North America. All three larval instars of the Hessian fly have been described in detail (Gagné and Hatchett 1989), but those of the wheat midge are less well known, and its first instar has not previously been described.

The general life history of the wheat midge or, in the United Kingdom, the orange wheat blossom midge, has been summarized by Reeher (1945) and Barnes (1956), and more information on certain aspects of its attack and feeding were treated by Mukerji et al. (1988) and Elliott and Mann (1996). Females lay eggs on emerging spikes of wheat before anthesis. Upon hatching, the larvae crawl to and settle upon the developing flower parts, where they feed and interfere with the proper development of the kernels. The full grown larva eventually drops from the wheat head, crawls into the soil, and constructs a silk cocoon in which the larva overwinters.

We show that the wheat midge has three larval instars, as do the Hessian fly and all other cecidomyiids that have been carefully studied (Gagné 1989). Upon hatching, the first instar of the wheat midge crawls to a feeding site on the developing wheat grain, settles, and begins to feed. Within two to three days the larva molts to the second instar, which continues to feed and grow until the third instar begins to develop. The second instar skin then becomes brittle and serves as a temporary cocoon for the third instar, which does not feed. The fully developed third instar can exit from the second instar skin immediately but may stay within this skin on the kernel for several weeks. Upon leaving the temporary cocoon, the third instar drops to the ground and burrows into the soil where it spins its cocoon.

In most other cecidomyiids the second instar skin is shed as soon as the third instar is fully developed and, in gall-making species, can be found crumpled in a compact mass at the caudal end of the third instar. The situation in the wheat midge is somewhat analogous to that of the Hessian fly in which the second instar skin also serves as a cocoon for the non-feeding third instar, with the difference that the third instar of the Hessian fly pupates there also. Because the Hessian fly feeds head groundwards between the culm and leaf sheath, the third instar has to reverse position from head to tail within the second instar skin. In this way the pupa of the Hessian fly is positioned so that adults are able to exit from the wheat sheaths. The third instar of the wheat midge is not so constrained, so does not need to reverse its position within the second instar skin. These two cecidomyiids on grasses are not closely related, each belonging to a different supertribe, so this rare development of a brittle second instar skin as a puparium or larvarium has evidently evolved separately. A puparium is present also in another grass-infesting gall midge, the sorghum midge, *Stenodiplosis sorghicola* (Coquillett) (Solinas 1986), which belongs to the same supertribe but to a different tribe than the wheat midge. A puparium is also known for other gall midges that do not occur on grasses but is still rare. Examples are *Thurauia aquatica* Rübsaamen from sedges in Europe and an undescribed species that belongs to no known genus from maple seeds in Japan.

The description and figures that follow will allow recognition of each of the three instars of the wheat midge. They are necessary to correct misinformation in Borkent (1989) that was based on mixed series of three species and in which it was asserted that the wheat midge had four instars.

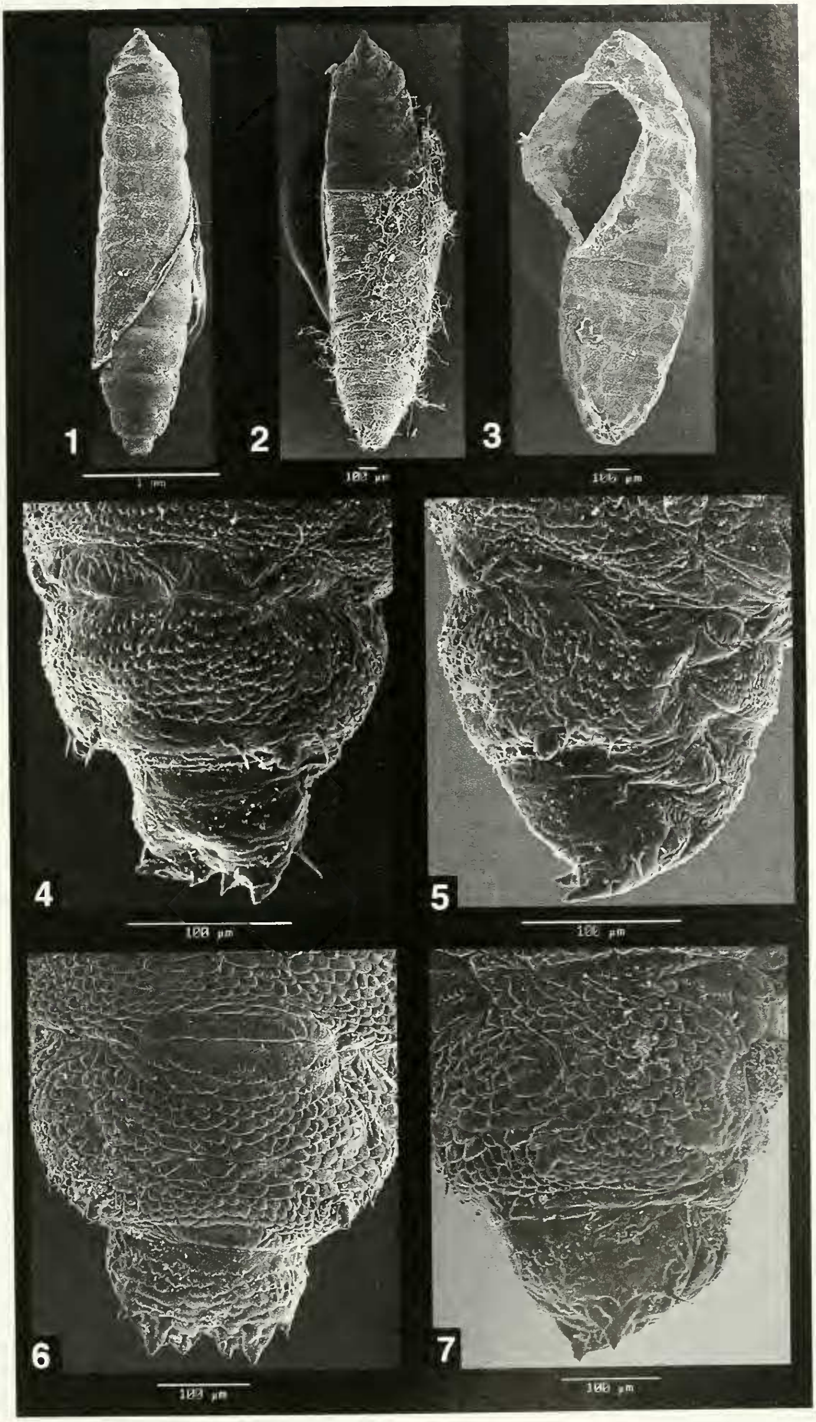
Methods

In 1997, collections of wheat heads (cultivar Roblin) were made by one of us (JFD) from a plot area (latitude 52.1951, longitude 106.1071) near St. Denis, a hamlet about 26 miles east of Saskatoon, Saskatchewan, Canada. Twenty-five primary heads were collected at intervals of 1 or 2 days from July 7 until July 18 and then at intervals of 3 to 4 days until July 31. The first eggs were found on the outside of the glumes on July 7 and the first newly hatched larvae on July 9. The larvae were removed from the heads and preserved in 70% alcohol for subsequent examination. Some specimens were mounted on microscope slides using the method outlined in Gagné (1989); earlier instars were mounted in Hoyer's medium because of their small size and the risk of their being lost in the various steps involved in balsam mounting. Terminology for larval morphology follows that in Gagné (1989).

Description of Larval Instars of *Sitodiplosis mosellana*

The first instar differs markedly from the remaining instars. It has only one pair of functional spiracles (Figs. 10, 12), which are situated on the eighth abdominal segment and are relatively large in relation to body size compared to the eighth abdominal spiracle of other instars (Fig. 13). Its cuticle is entirely smooth except for several horizontal rows of tiny spicules dorsally and ventrally near the anterior part of most segments (Figs. 11, 12). The second and third instars each have spiracles on the first thoracic and on the first through eighth abdominal segments. The cuticle of the second and third instars is rough, covered almost entirely by raised scale-like bumps (Figs. 4–7). The third instar differs from the second in having a spatula, the clove-shaped dermal structure on the venter of the prothorax (Fig. 9). Because this structure begins to develop while the third instar is still encased in the second instar, the spatula is usually visible through the skin of older second instars. An additional difference between the second and third instars is that the two caudalmost terminal papillae are more equal in size in the third instar than in the second (Fig. 14). A more detailed description follows:

First instar (Figs. 10–12).—Body length 0.45–1.05 mm. Antenna three times as long

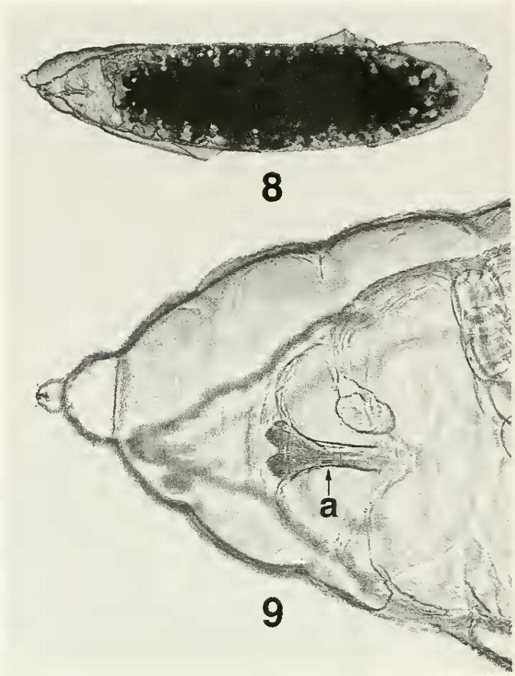


Figs. 1–7. *Sitodiplosis mosellana.* 1–3, Brittle second instar skins from which third instar is emerging (1, 2) or has emerged (3). 4, Second instar (dorsolateral). 5, Same (lateral). 6, Third instar (dorsal). 7, Same (lateral).

as wide. Two pairs of spiracles apparent, one on prothoracic segment, the other on eighth abdominal segment: prothoracic pair evident only as short projection, evidently not functional; posterior pair prominent, with three acute apical projections. Cuticle smooth except for several horizontal rows of tiny spicules dorsally and ventrally near anterior part of each segment except for prothorax. Pattern and number of papillae basic for supertribe Cecidomyiidi, their setae mostly very short, dorsal and pleural papillae of eighth segment slightly longer than preceding segments, and terminal papillae modified as follows: one dorsal, subcaudal pair with short setae not surpassing length of those on preceding segments; one lateral pair with elongate setae several times longer than subcaudal pair; two caudal pairs with stout, wide setae, the outer of these two pairs more than twice length of inner pair.

Second instar (Figs. 4, 5, 8, 9, 14).—Body length 1.05–3.30 mm. Antenna about twice as long as wide. Spiracles present on prothoracic and first through eighth abdominal segments, eighth abdominal pair slightly larger than preceding spiracles, none with apical projections. Cuticle rugose, covered almost completely with raised scale-like bumps, these much smaller and arranged in several regular anteroventral horizontal rows on mesothoracic to eighth abdominal segments. Pattern of papillae similar to that of first instar but setae more conspicuous. Terminal papillae modified as follows: two lateralmost papillae with setae, the more ventral pair with longer setae; two pairs with stout setae, the inner pair with setae noticeably thinner than outer pair.

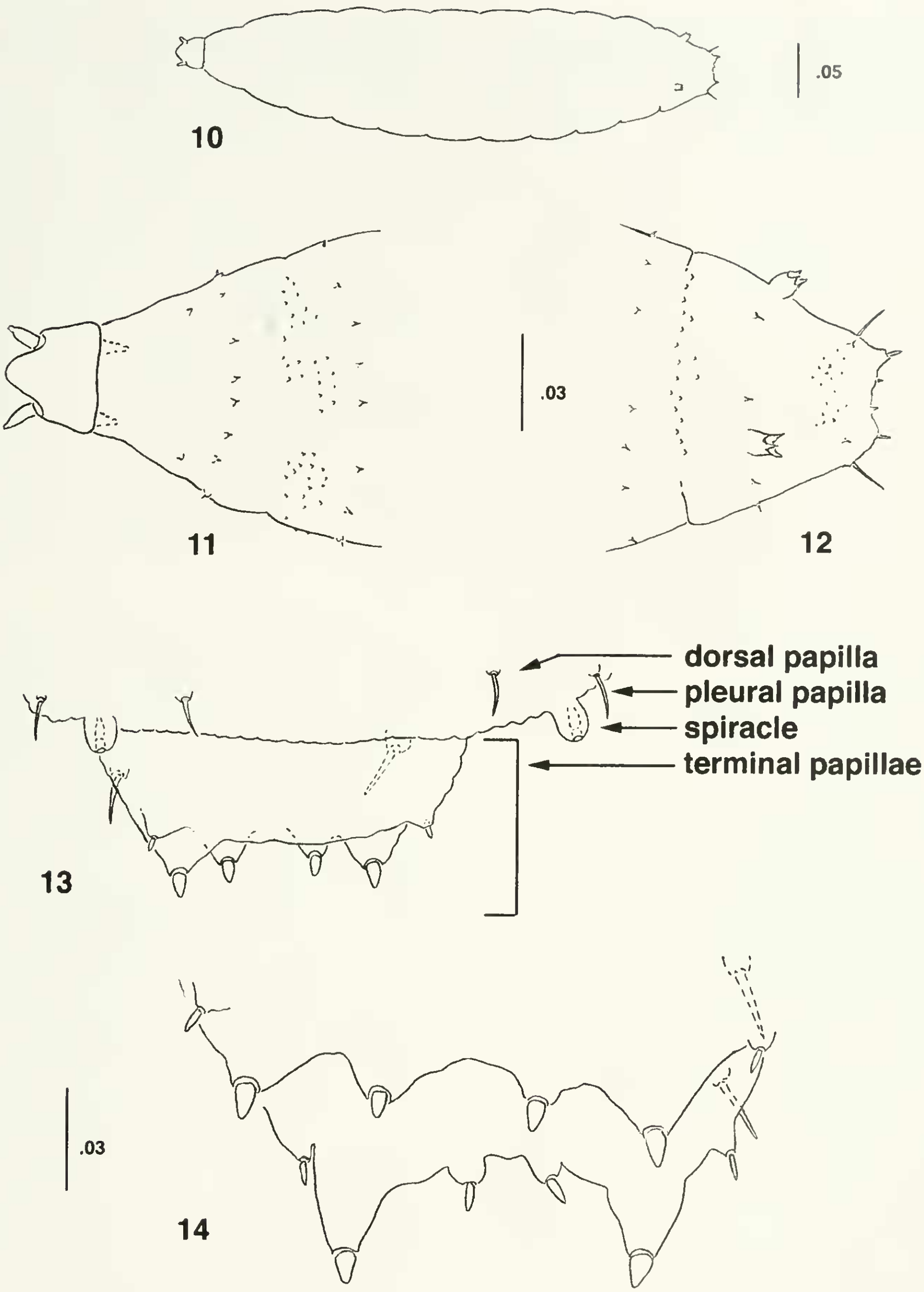
Third instar (Figs. 6–9, 13, 14).—Body length 2.80–3.20 mm. Antenna and spiracles as for second instar. Cuticle also as for second instar except for presence of ventral prothoracic spatula and horizontal anteroventral rows of bumps more numerous and more extensive. Pattern of papillae similar to that of second instar. Terminal papillae modified as for second instar except inner pair of caudal, stout setae more nearly equal in size to outer pair.



Figs. 8, 9. *Sitodiplosis mosellana*. 8, Third instar inside second instar skin (ventral). 9, Detail of same (a = spatula).

Remarks.—Borkent (1989) described and illustrated four alleged instars for the wheat midge, each with a spatula. The first instar of that paper is a third instar of an undetermined *Clinodiplosis* sp. Its posterior abdominal segment, as illustrated in his Fig. 2A, has three of the four pairs of terminal papillae corniform (short and stout) and only one pair setiform, characteristic of species of *Clinodiplosis*. The presence of a spatula indicates that the specimen is a third instar. Specimens of these larvae occasionally are found in association with wheat midge larvae. Representatives of this species in the USNM are curated with wheat midge larvae until adults are reared and the species can be identified further.

The second instar of Borkent (1989) is a third instar of an undescribed species of *Contarinia* (broad sense). It has one pair of



Figs. 10–14. *Sitodiplosis mosellana*. 10, First instar (dorsal). 11, Same, detail of head and first two thoracic segments. 12, Same, detail of posterior segments. 13, Third instar, posterior part of eighth segment and terminal segment (dorsal). 14, Juxtaposed third instar (upper) and second instar (lower) terminal segments (dorsal). Bar lengths are in mm.

corniform (short and stout) papillae and three pairs of setiform papillae, two of which are of similar size. The presence of a spatula indicates that this specimen is also a third instar. Specimens in the USNM of similar larvae found in association with the wheat midge also have a spatula and are definitely third instars. These are also temporarily curated with wheat midge larvae until adults are found that can be identified further.

The third and fourth instars of Borkent (1989) are actually the second and third instar, respectively, of the wheat midge. Both are described in that paper as having a spatula, but the second instar has none. As noted above, older specimens of the second instar may appear to have a spatula due to the developing third instar inside (Figs. 8, 9). One can be certain of the train of instars of a particular species by observing nearly fully developed preecdysal instars within the body of a previous instar, as we have done here.

Borkent (1989) cited Borkent (in press), "Description of the larval instars of the Wheat Midge *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae). Can. J. Zool." No paper by Borkent on the subject of the wheat midge has appeared in the Canadian Journal of Zoology.

This occasion is taken to remove the name *Cecidomyia amyotii* Fitch from synonymy with the wheat midge. Felt (1925) listed *C. amyotii* as "probably a synonym of" the wheat midge and Foote (1965) cataloged it as a synonym of the wheat midge for the first time. According to Fitch's (1861) original description of *C. amyotii*, based on three specimens caught at a light, the female antenna has "eighteen (?) joints, not separated by pedicels, the joints globular." The female of the wheat midge has 12 antennal flagellomeres, each separated by a conspicuous pedicel or neck, so *C. amyotii* cannot be the wheat midge. Because the types of *C. amyotii* are presumably lost and the species cannot be determined with certainty, we consider this species a dubious name.

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Literature Cited

Barnes, H. F. 1956. Gall Midges of Economic Importance, Vol. 7: Gall Midges of Cereal Crops. Crosby Lockwood & Son, London. 261 pp. and 16 pls.

Borkent, A. 1989. A review of the wheat blossom midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae) in Canada. Agriculture Canada Research Branch Technical Bulletin 1989–5E. Ottawa, Ontario. 18 pp, 6 pls.

Elliott, R. H. and L. W. Mann. 1996. Susceptibility of red spring wheat, *Triticum aestivum* L. CV. Katepwa, during heading and anthesis to damage by wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae). The Canadian Entomologist 128: 367–375.

Felt, E. P. 1925. Key to gall midges (a resumé of studies I–VII, Itonididae). New York State Museum Bulletin 257: 1–239, pls. 1–8.

Fitch, A. 1861. Sixth report on the noxious and other insects of the State of New York. New York State Agricultural Society Transactions (1860) 20: 745–868, pls. 1–2.

Foote, R. H. 1965. Family Cecidomyiidae. *In* Stone, A., C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson, eds., A Catalog of the Diptera of America North of Mexico. U.S. Department of Agriculture Handbook 276, 1696 pp.

Gagné, R. J. 1989. The Plant-Feeding Gall Midges of North America. Cornell University Press, Ithaca, New York. xiii, 355 pp., 4 pls.

Gagné, R. J. and J. H. Hatchett. 1989. Larval instars of the Hessian fly (Diptera: Cecidomyiidae). Annals of the Entomological Society of America 82: 73–79.

Mukerji, M. K., O. O. Olfert, and J. F. Doane. 1988.

Development of sampling designs for egg and larval populations of the wheat midge, *Sitodiplosis mosellana* (Géhin) (Diptera: Cecidomyiidae), in wheat. The Canadian Entomologist 120: 497–505.

Reeher, M. M. 1945. The wheat midge in the Pacific Northwest. United States Department of Agriculture Circular 732: 1–8.

Solinas, M. 1986. *Allocontarinia*, n.g., *A. sorghicola* (Coq.) n. comb. (Diptera, Cecidomyiidae). Entomologica 21: 23–35.